MIL-I-83456 (USAF)
20 December 1974

MILITARY SPECIFICATION

INSTALLATION OF SEGMENTED LIGHTNING DIVERTER STRIPS ON AIRCRAFT RADOMES, GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 This specification covers the general requirements for installation of segmented lightning diverter strips on aircraft radomes.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on date of invitation for bids or request for proposal form a part of the specification to the extent specified herein.

SPECIFICATIONS

Federal

TT-M-261	Methyl Ethyl Ketone, Technical

Military

MIL-B-5087	Bonding, Electrical, and Lightning Protection
MIL-R-7705	Radomes, General Specification
MIL-S-8516	Sealing Compound, Polysulfide Rubber, Electric Connectors and Electric Systems, Chemically cured
MIL-A-83377	Adhesive Bonding for Aerospace Systems, Guidelines for

STANDARDS

Military

MIL-STD-810	Environmental Test Methods

3. REQUIREMENTS

FSC 5841

3.1 General. The diverter strips shall be bonded on the exterior surface of the radome to provide an electrostatic shield for the antennas and other metallic objects within the radome. The diverter strip-radome combination shall meet the requirements of MIL-R-7705 and the radome detail specification, and the requirements outlined herein.

3.2 Materials. The materials employed in installing the segmented diverter strips to the radome shall have structural, electrical and environmental characteristics compatible with the requirements of this specification.

3.2.1 Coatings. Coatings shall not be applied over the exposed metal segments of the diverter strip.

3.3 Installation Design.

3.3.1 Dimensions. Dimensions shall be in accordance with the radome detail specification and the applicable installation drawing.

3.3.2 Environmental. The radome diverter installation shall meet the requirements of this specification after exposure to sunshine, humidity, salt fog, and vibration.

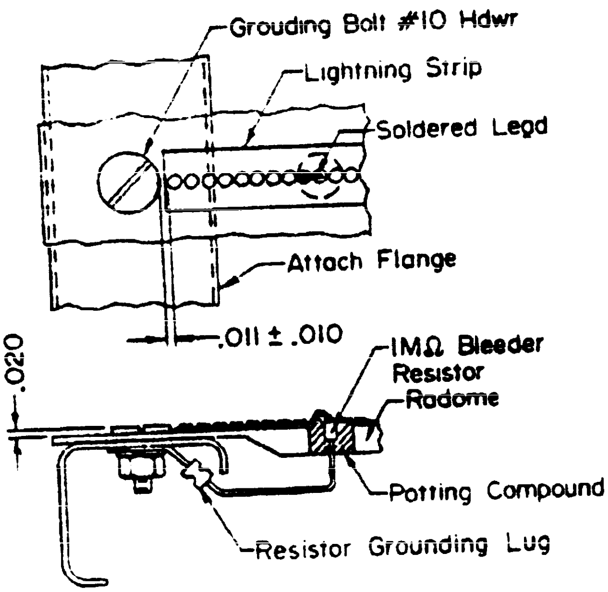
3.3.3 Performance.

3.3.3.1 Structural.

3.3.3.1.1 Adhesion. The requirements for the adhesion of the diverter strips to the radome shall be established considering structural loads and temperatures specified in the radome detail specification. The diverter strips shall be bonded to the radome to meet the requirements thus established.

3.3.3.2 Electrical.

3.3.3.2.1 Electrical Bond. The diverter strips shall be electrically connected to metal structure at the base of the radome. The resistance between the grounding bolt and attach flange shall not be greater than 0.01 ohm. As an alternate method the strips may be grounded to the attach flange through a resistor. Where a resistor is used to ground the diverter strip, the resistance to ground shall be as specified in the radome detail specification or the diverter installation drawing. Typical methods of electrical bonding the diverter strips are shown in Figure 1. These methods may also be used to electrically connect the diverter strip to pitot booms when required.

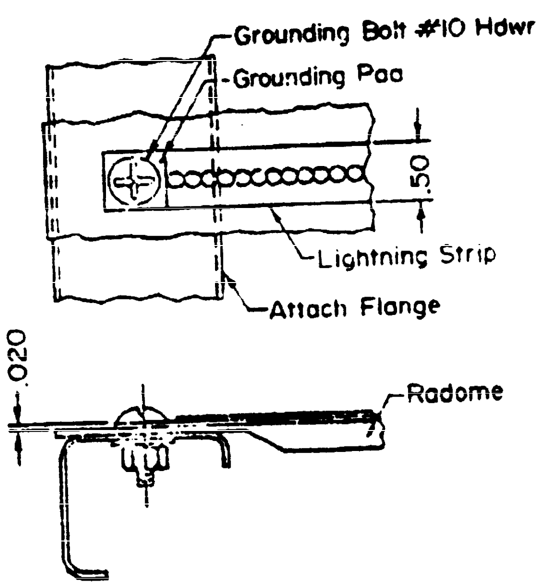


Method A

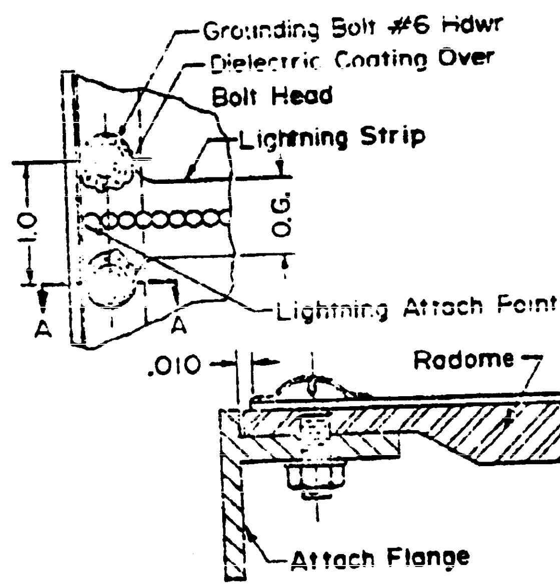
A. Grounding of Diverter Strip thru Bleeder Resistor - No Special Connector required at the end of the Strip - Lightning attaches directly to the grounding bolt.

B. Grounding of Diverter Strip using #10 bolt through connector on the end of the strip. Lightning attaches directly to the grounding bolt.

C. Grounding of strip using butterfly connector - bleeder resistor is incorporated in the strip between the segments and the #6 grounding screw - Lightning attaches to the attach flange.



Method B



Section "A-A"

Method C

Figure 1. Typical Methods of Electrically Grounding the Segmented Diverter Strips

3.3.3.2.2 Resistance. The electrical resistance of the diverter strip between the outermost segment and ground shall be as specified by the manufacturer of the segmented strips. (All designs do not require the same resistance.)

3.3.3.2.3 Microwave Performance. The radome with the lightning diverter strips installed shall meet system performance requirements as specified in MIL-R-7705 and the detail specification.

3.3.3.2.4 Lightning Protection.

3.3.3.2.4.1 Shielding. The diverter strip installation shall protect the radome and all associated antennas, pitot tubes, heater wires, air data lines, tuning wires, or other equipment installed under the radome, from lightning strikes from all possible directions as determined by laboratory high voltage tests.

3.3.3.2.4.2 High Current Tests. The diverter strip installation, including all attachment and grounding fittings, shall be capable of transferring high current multiple component lightning waveforms without damage to the radome and all associated antennas, pitot tubes, heater wires, air data lines, tuning wires, or other equipment installed under the radome. Each installed diverter strip shall be capable of transferring at least 10 successive multiple component waveforms without replacement of the strip. Diverter strips used for protecting pitot tubes shall withstand 25 multiple components.

3.4 Workmanship. There shall be a continuous bond of the diverter strip to the radome with no voids at the edges. The bonded strip shall be free of excessive adhesive and other surface defects.

4. QUALITY ASSURANCE PROVISIONS

4.1 Classification of tests. The inspection and testing of diverter strip installations on radomes shall be classified as follows:

a. Preproduction Tests: Preproduction tests shall consist of all inspection and test items outlined under paragraph 4.0 of this specification. Preproduction tests shall be performed on a radome-diverter strip system representative of the production installation prior to production release.

b. Acceptance Tests: Acceptance tests shall consist of all inspection and test items outlined under paragraphs 4.2, 4.3.3.1 and 4.3.3.2. Acceptance tests shall be performed on each radome submitted for acceptance.

4.2 Inspection

4.2.1 Dimensions. The location and tolerances for the bonded diverter strips shall be inspected for conformance to the requirements specified in paragraph 3.2.1.

4.2.2 Workmanship. The bonded diverter strips shall be visually inspected with a 4X magnification glass to show conformance with the requirements specified in paragrpahs 3.2.1 and 3.4.

4.3 Testing.

4.3.1 Environmental. The radome with the lightning diverter strips installed shall be tested per MIL-STD-810 to show conformance with the requirements of paragraph 3.3.2. The detail requirements outlined under paragraph 4.0 of each required Test Method in MIL-STD-810 shall be specified in the radome detail specification.

4.3.2 Structural

4.3.2.1 Adhesive Bond. The bond of the diverter strip to radome shall be tested in accordance with MIL-A-83377 to show conformance with the requirements of paragraph 3.3.3.1.1.

4.3.3 Electrical

4.3.3.1 Electrical Bond. The resistance between the grounding bolt and the attach flange of the radome shall be measured with a milliohmmeter to show conformance with the requirements of paragraph 3.3.3.2.1. Where a resistor is used to ground the diverter strip, the resistance to ground shall be measured with a megohmmeter to show conformance with the radome detail specification or the diverter installation drawing.

4.3.3.2 Diverter Strip Resistance. The resistance of diverter strips shall be tested after installation using a megohmmeter with metal probes. One probe shall contact the metal button or segment at one end of the strip and the other probe at the other end of the strip. The resistance shall meet the requirements of paragraph 3.3.3.2.2.

4.3.3.3 Microwave Tests. The radome with the diverter strips installed shall meet the requirements of paragraph 3.3.3.2.3 when tested in accordance with MIL-R-7705 or the detail specification.

4.3.3.4 Simulated Lightning Tests.

4.3.3.4.1 High Voltage Tests. The lightning diverter strip installation shall meet the requirements of 3.3.3.2.4.1, when tested in accordance with Appendix A.

4.3.3.4.2 High Current Transfer Tests. The lightning diverter strip installation shall meet 3.3.3.2.4.2 when tested in accordance with Appendix B. Each strip will be tested over its entire length.

4.3.4 Waiving of Tests. Preproduction tests may be waived by the procuring government agency when it can be shown that a proposed installation is equivalent to a previously tested installation. Lightning tests will be waived only if written authority is obtained in accordance with AFR 80-23.

5. PREPARATION FOR DELIVERY

The radome with lightning diverter strips installed shall be prepared for delivery in accordance with MIL-R-7705 and the radome detail specification.

6. NOTES

6.1 Diverter Strip Description. Segmented diverter strips are a series of metal segments connected by resistors on a dielectric substrate. These strips can withstand repeated lightning strikes and can be used on radomes having severe microwave and aerodynamic performance requirements. The diverter strips are normally installed parallel to the airstream to minimize drag. The spacing between the strips usually will range from 12 to 24 inches depending on the dielectric strength of the radome and the shape and closeness to the radome wall of enclosed metal objects.

6.2 Installation Methods. Typical methods for bonding diverter strips are listed here for information purposes. Their adequacy will depend on the particular system requirements. When available, methods for installing higher temperature segmented diverter strips will be added as amendments or revisions.

6.2.1 Method #1. Bonding of diverter strips, painted on the top and bottom with polyurethane paint, to radomes coated with polyurethane paint. (Limited to a maximum temperature of approximately 200°F.)

a. Clean surfaces to be bonded with cheesecloth dampened with MEK (TT-M-261). Do not flood surfaces as this may damage the radome finish.

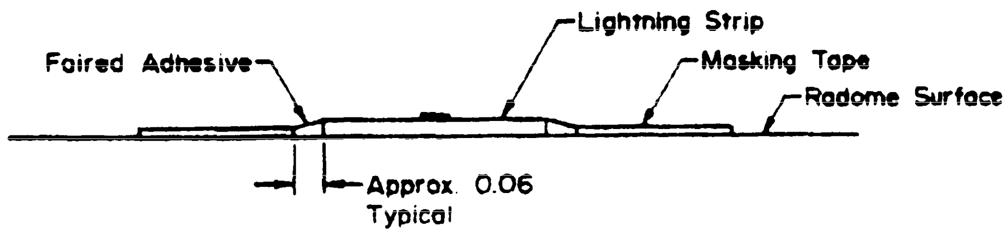
b. Apply masking tape to the radome adjacent to bonding area in order to restrict application of primer and adhesive to the bond areas only. Spacing of the masking shall be sufficient to allow a bead of adhesive to form on each side of the diverter strip.

c. Apply a thin coat of Dow Corning RTV 1200 primer to all bond surfaces with a brush or cheesecloth dampened with primer. A thin continuous coating is desired. The primer shall not be used after it becomes milky or cloudy. Allow the primer to dry 30 minutes minimum and four hours maximum before bonding.

d. A uniform layer of Dow Corning 30-121 adhesive, approximately 15 to 20 mils thick shall be applied to one of the surfaces to be bonded. Bond surfaces shall be joined as soon as possible after applying adhesive. The adhesive will form a surface skin within a few minutes which will interfere with adhesion. Care shall be taken to assure that adhesive is not applied to the radome outside of the masked areas.

e. The diverter strips shall be applied with sufficient pressure to obtain a continuous extrusion of adhesive at the edges. A bondline thickness of 5 - 10 mils is desired.

f. Excessive extruded adhesive shall be removed leaving a faired fillet as shown below. This can most easily be accomplished by wiping the edge of the lightning strip with a tool or dry cheesecloth before the adhesive skins over. No voids are allowed under strips. Additional adhesive may be applied if necessary.



g. Masking tape is recommended for holding the lightning strips in position while the adhesive cures. Adhesive shall cure a minimum of 24 hours at 70 to 80 degrees F.

h. All masking tape shall be removed after adhesive has cured. No voids are allowed under strips. Additional adhesive may be applied if necessary to fill any remaining voids with curing to be accomplished per g. above.

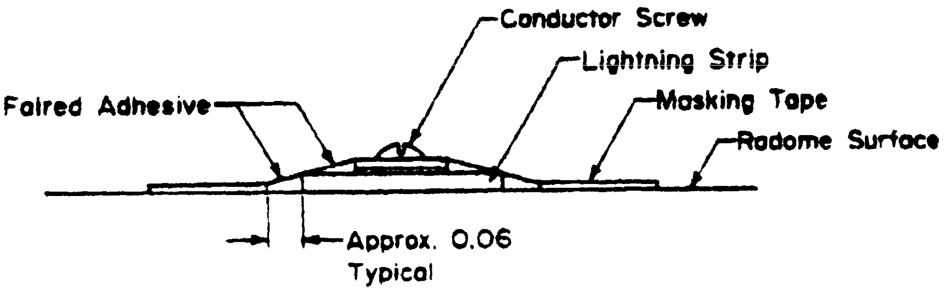
i. The conductor screws shall be installed per the radome drawing with surface seal as follows:

(1) Clean all surfaces to be sealed (see below) with cheesecloth dampened with MEK. Do not flood surfaces. Dry thoroughly with a clean cloth.

(2) Install the grounding screw at the end of the strip.

(3) Prime all surfaces to be sealed per c. above.

(4) Apply a faying surface seal of Dow Corning 30-121 adhesive/ sealant around each conductor screw. Sufficient material shall be applied so that there will be no voids around the installed conductor screw. Remove excessive sealant and fair in the edges of the diverter strip and around the conductor screw as shown below. The head of the grounding screw shall be exposed in the area directly adjacent to the segments. No adhesive is allowed on the segments.



6.2.2 Method #2. Bonding diverter strips with epoxy substrates to epoxy radomes. (Limited to a maximum temperature of approximately 170° F.)

a. Clean surfaces to be bonded with cheesecloth dampened with MEK (TT-M-261). Allow to air dry.

b. Apply masking tape to the radome, adjacent to bonding area in order to restrict application of the adhesive to the bonding areas only. Spacing of masking tape shall be sufficient to allow a bead of adhesive to form on each side of the diverter strip.

c. Abrasive clean the areas to be adhesive bonded by sanding the area with 100 grit sandpaper until surface gloss and all contamination have been removed.

d. Remove residual dust and abrasive from the surface by use of a vacuum cleaner equipped with a bristle brush. Ensure that the brush has been thoroughly cleaned with MEK (TT-M-261) and dried before use.

e. Handle cleaned parts with clean white gloves.

f. The EC-2216 is a two-part adhesive from 3M Company. Mix the components thoroughly in a clean container in the following proportions until a homogenous mixture is achieved:

Resin Base B - 100 parts by weight
Hardener A - 140 parts by weight

g. Apply the thoroughly mixed adhesive, using a brush to apply a thin smooth coating on the diverter strip and the radome, or nonmetallic surface. Coating thickness shall be 5 to 6 mil (0.005" to 0.006") thick. Do NOT allow any of the adhesive on the segment surface of the diverter strip.

h. Position the diverter strip on the radome or non-metallic surface. Press or roll the entire diverter strip to achieve good contact. Apply small strips of masking tape (approximately one inch) on the diverter strip at no more than 12" intervals to maintain intimate contact to the radome or non-metallic surface.

i. Cure at room temperature (not less than 60 degrees F.) for 24 hours before removing the masking tape. Optimum cure time at this temperature will be attained in seven days. If a shorter cure time is desired, heat the assembly to 150 degrees F. ± 10 degrees F. for four hours. (Allow the adhesive to gel before applying heat.) Permit the assembly to remain undisturbed during curing.

j. Use EC-2216 adhesive to seal double terminated diverter strip forward termination attachment hardware and strip edges to prevent moisture from collecting under the strip.

k. Where a bleeder resistor is used, terminate the bleeder resistor pigtail on the grounded metal hardware. Electrical bonding shall be in accordance with MIL-B-5087.

l. The body of the bleeder resistor shall be potted into the radome or non-metallic material with polysulfide compound, MIL-S-8516.

6.2.3 Method #3. Bonding of diverter strips with epoxy substrate to epoxy radomes (limited to a maximum temperature of 300°F).

a. Both the radome surface, in the bond areas, and the diverter strips shall be cleaned with a cheesecloth dampened with MEK (TT-M-261). Air dry for 15 minutes. Apply masking tape to the radome, adjacent to bonding area and on the diverter center strip of resistant material. Abrasive clean the radome and diverter areas to be adhesive bonded with 100 grit sandpaper until a fresh glass-fiber surface is revealed. Remove residual dust and abrasive from the radome and diverter surfaces by use of a vacuum cleaner. Handle cleaned parts with clean white gloves.

b. A one to two mil thick coating of BR-96 adhesive (American Cynamid Company) shall be brush-applied to the bonding surface of the segmented strip and the radome. Areas of the radome adjacent to the bonding area shall be masked. Radome and strips shall be oven dried for 30 to 60 minutes at 180 - 200 degrees F. prior to fit-up for bonding.

c. The diverter strips shall be positioned per the applicable radome drawing onto the adhesive-coated surface. Small strips of removable tape shall be applied across the strip at approximately 12" intervals to eliminate slippage.

d. Each diverter strip shall be covered with a strip of F58 release fabric or equivalent bleeder (Hexcel Corporation).

e. The external radome surface shall be enclosed with a nylon film bag and a minimum of 24" Hg vacuum pressure applied and maintained throughout cure.

f. The radome assembly shall be placed in an oven. Air temperature shall be raised to 300 degrees F. at a rate of 3.5 to 4.0 degrees per minute. The bondline temperature shall be held at 300 degrees ±10 degrees F. for four hours plus or minus 15 minutes. The radome shall be cooled under vacuum bag pressure.

g. Where a bleeder resistor is used, a No. 70 (0.028 dia.) hole shall be drilled through a button center and through the radome shell just forward of the metal attach hardware. A 1/8" diameter hole shall also be countersunk about ½ the laminate thickness.

h. The leads of the resistor shall be soldered to the points of attachment to the diverter button and metal hardward (ground).

i. The hole shall be potted with adhesive Bloomingdale BR-96 and the adhesive cured one hour at 180-200 degrees F. plus one hour minimum at 330 degrees F.

Custodian:
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Air Force - 11

Project Number: 5841-F039

APPENDIX A

HIGH VOLTAGE ATTACHMENT POINT TESTS

10. SCOPE

This attachment point test determines the specific attachment points on the external surface, and the path taken by the lightning arc in reaching a metallic surface.

20. WAVEFORM

Test waveform V-A shall be applied (See figure 1).

30. TEST SETUP

The test radome shall be a full scale production line hardware component or a representative prototype, since minor changes from design samples or prototypes may change the lightning test results. All conducting objects within the radome shall be simulated and shall be electrically connected to ground (the return side of the lightning generator). Surrounding metallic vehicle mounting structure should be simulated and attached to the test radome to make the entire test object look as much like the actual vehicle region under test as possible.

The test electrode to which test voltage is applied should be positioned so that its tip is about 1 meter away from the nearest surface (either metallic or nonmetallic) of the test radome Dimensions of the test electrode are not critical. Generally, model tests or field experience have indicated that lightning flashes can approach the object under test from several different directions.

The tests shall be repeated with the high voltage electrode oriented to create strokes to the radome from these different directions.

A 1-meter rod-plane gap will flash over at 1300 kV after a 1000 kV/μsec rate of rise; however exact voltage amplitude is left unspecified because it is dependent upon the other two parameters of gap length and rate of voltage rise. As long as rate of rise is specified, longer gaps will receive greater voltage and shorter gaps less, in accordance with the natural breakdown process. Multiple flashovers should be applied from each electrode position. Tests may be commenced with either positive or negative polarity. If test electrode positions are found from which the simulated lightning flashovers do not contact the test piece, or do not puncture it if it is nonmetallic, the tests from these same electrode positions should be repeated using the opposite polarity.

40. MEASUREMENTS AND DATA REQUIREMENTS

Measurements that shall be taken during this test include the following:

40.1 Test Voltage Amplitude And Waveform. The voltage applied to the gap should be measured by a voltage divider and oscilloscope. Photographs of the voltage waveform shall be taken to establish that waveform VA is in fact being applied.

40.2 Voltage measurements shall be made of each test voltage waveform applied since breakdown paths, and hence the test voltage may change. Particular attention should be given to assuring that the gap flashes over on the wavefront (rise). If a flashover occurs on the wave tail the test should be repeated with the generator set to provide a higher voltage or the test electrode positioned closer to the test object so as to produce flashover on the wavefront.

50. NOTES

The voltage generators used for these tests are high impedance devices. The test current is much less than natural lightning currents. Consequently, they will produce much less damage to the test object than a natural lightning flash, even though the breakdown will follow the path a natural lightning stroke current would follow. Occasionally, a diligent search will be required to find the attachment point on metals or the breakdown path through nonmetallic surfaces. These attachment points or breakdown paths should be looked for after each test and marked, when found, with masking tape or crayon markings to prevent confusion with further test results.

APPENDIX B

HIGH CURRENT TESTS

10. SCOPE

These tests determine the direct effects which lightning currents cause to the diverter strips or to the radome.

20. WAVEFORMS

Tests of radomes require application of multiple waveform components in one discharge; apply waveforms I-A, I-C, and I-D in this order, see figure 2.

30. TEST SETUP

30.1 Test Electrode and Gap

The test currents are normally delivered to the test radome from a test electrode positioned adjacent to it. The test radome is usually grounded to the return side of the generator (s) so that test current can flow through the object in realistic manner.

The electrode material should be a good electrical conductor with ability to resist the erosion produced by the test currents involved. Yellow brass, steel, tungsten and carbon are suitable electrode materials. The shape of the electrode is usually a rounded rod firmly affixed to the generator output terminal and spaced a fixed distance above the surface of the test radome.

If a blunt electrode is used with a very small gap, the gas pressure and shock wave effects in the confined area may cause more physical damage then would otherwise be produced. The gap spacing therefore should be kept as great as the output voltage capabilities of the generator(s) will allow and the electrode should be rounded to allow relief of the pressure formed by the discharge. A gap spacing of one centimeter is recommended.

30.2 For multiple component tests, the test electrode should be placed as far from the test object surface as the driving voltage of continuing current component (C) will allow. When this component is preceeded by the high peak current component (A), the high driving voltage of this generator initiates the arc and components C and D follow the established arc even though driven by a lower voltage.

30.3 The polarity of the high peak current (A) and restrike (D) components can be either positive or negative. The polarity of the C component generator (s) should be set so that the electrode is negative with respect to the test object because greater damage is produced when the test object is at positive polarity with respect to the test electrode.

40. MEASUREMENTS & DATA REQUIREMENTS

Measurements that shall be made during these tests are TEST CURRENT AMPLITUDE(S) AND WAVEFORM(S). Initial stroke, restrike and intermediate current components may be measured with noninductive resistive shunts, current transformers or Rogowski coils. Continuing currents may be measured with resistive shunts. The output of each of these devices should be measured on a suitable oscilloscope and recorded by photography of the oscilloscope trace.

Since the condition of the test object or other parts of the test circuit may affect the test current(s) applied, oscillographic measurements of these parameters should be made during each test applied.

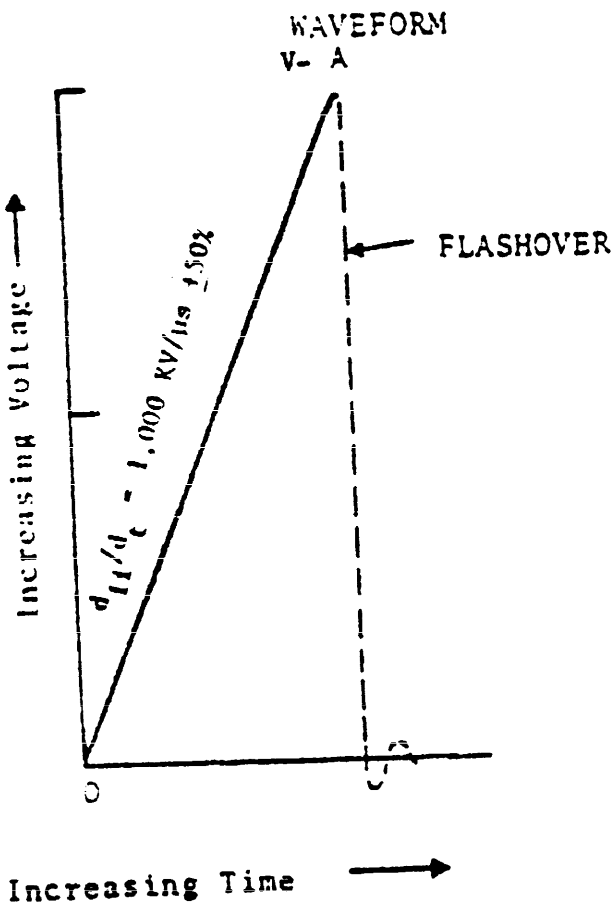

Figure 1 High Voltage Test Waveforms
(Notes: 1. Time Scale is not linear)

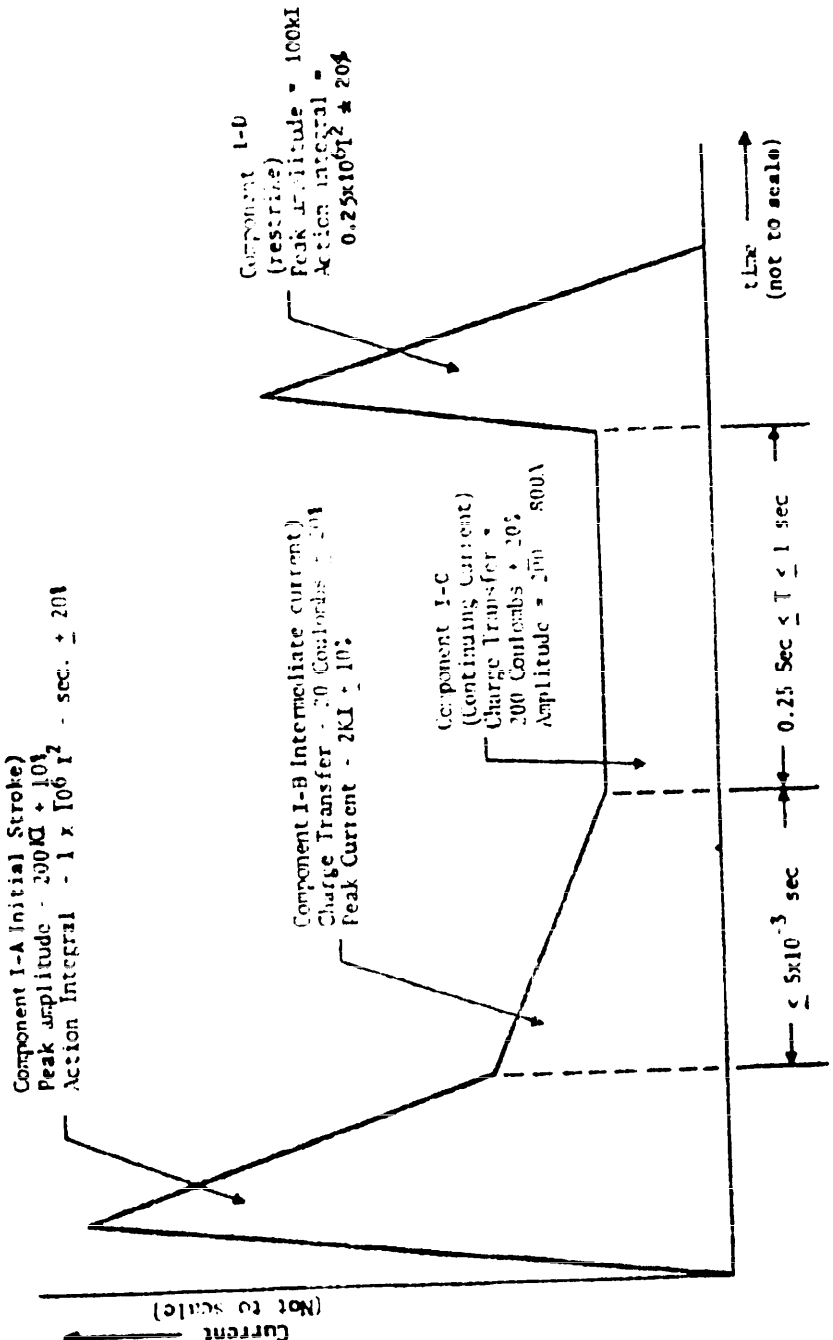

Figure 2 Current Test Waveform Components

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